STRATIGRAPHY.—*The stratigraphic significance of* Kummelia, *a new Eocene bivalve genus from New Jersey.*[1] LLOYD W. STEPHENSON, U. S. Geological Survey.

The tube of a boring bivalve mollusk from the Vincentown sand (Rancocas group, Eocene) was described by Gabb (1) in 1860, under the name *Gastrochaena americana.* At that time the Vincentown was classed as Upper Cretaceous, and it was not until 1928 that Cooke and Stephenson (2) reassigned the formation, together with the underlying Hornerstown marl of the Rancocas group, and the overlying Manasquan marl, to the Eocene. Tubes of boring mollusks found in beds of undoubted Upper Cretaceous age, in the Atlantic and Gulf Coastal Plain, were referred to Gabb's species by Gabb himself and by Weller and others, but, as shown below, this identification was erroneous.

In 1861 Gabb reassigned his *Gastrochaena americana* to his new genus *Polorthus* in the belief that the tube was a conch and pertained to a gastropod near *Vermetus.* In 1872 Gabb reassigned *Polorthus americanus* to the Cephalopoda and made it the type of a new family, Polorthidae; this was done because he had come to believe that the suture-like grooves separating the annulations on the exterior of the tube indicate a chambered, septate conch.

That Gabb was mistaken in both of these reassignments, and that his *Polorthus americanus* is an external, protective calcareous tube secreted by a boring bivalve mollusk, can now be demonstrated. The present author has had the good fortune to find in the tubes specimens of the bivalve mollusks responsible for the construction of the tubes, both those in the Vincentown sand and those in the Upper Cretaceous sediments; the evidence afforded by these shells demonstrates clearly that the animal that secreted the Eocene tubes is both generically and specifically distinct from the one that built the Cretaceous tubes. The differences which serve to separate the two kinds of shells and tubes are indicated in the formal description given below. The Cretaceous shells and their tubes are strikingly like those of the true *Gastrochaena* Spengler, a Recent bivalve inhabiting the waters of the Indian and West Pacific Oceans, whereas both the Eocene shell and its tube are essentially different from *Gastrochaena.* Although the shells found in the tubes from the Eocene are similar in form to *Roscellaria* Blainville, a Recent shell, the Eocene tube is

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strikingly different from that of *Roscellaria*, for which reason, and also because of the great separation in time, it seems reasonable to assign the Eocene shell to a new genus. The name proposed is *Kummelia*.

One incomplete tube of a boring mollusk, found by Dr. John B. Reeside, Jr., September, 1931, in the Piscataway member of the Aquia formation (Eocene), in a road cut just east of the West Branch of Patuxent River three fourths of a mile west of Oak Grove, 2.6 miles west of Leeland, Prince Georges County, Maryland (3), is essentially like that of *Kummelia americana* (Gabb); the shell itself was subsequently uncovered within the tube and it confirmed the identification. The shell and tube are shown in Figures 6–8. The road cut exposes about 15 feet of greensand, several layers of which are indurated. The tube was found in a loose fragment of one of the indurated layers; associated with the tube in the same piece of rock were several shells of *Terebratula harlani* Morton.

The finding of *Kummelia americana* (Gabb) in the Aquia formation of Maryland affords further confirmatory evidence of the Aquia (Eocene) age of the Rancocas group of New Jersey. The Oak Grove locality is stratigraphically well below a zone in the Paspotansa member of the Aquia formation (3) from which 23 species of Bryozoa have been recorded by Canu and Bassler (4); 6 of the 23 species are common to the Vincentown sand. Since the Vincentown has yielded 85 species of Bryozoa, this relatively small number of common species does not necessarily indicate exact age equivalency of the containing beds in Maryland and New Jersey; but there is a reasonable presumption that they do not differ greatly in age, and the position of the Oak Grove locality below the bryozoan zone suggests that it is of Hornerstown age.

In the summer of 1936, Mr. P. E. Cloud of the U. S. National Museum, made a collection of fossils from the Hornerstown marl in a pit of the Zeolite Chemical Company, 2 miles north of Medford, Burlington County, N. J. The fossils are mainly in the form of internal molds and include: An unidentified coral (common); an unidentified sponge (numerous); *Cucullaea* sp. (numerous); *Venericardia* (of the *planicosta* group); *Meretrix*?; *Polinices* sp.; *Pleurotomaria*?, and several unidentified gastropods. Of the forms mentioned the *Venericardia* may be accepted as satisfactory evidence of the Eocene age of the Hornerstown marl. The *Cucullaea*, though specifically indeterminate, has a form suggestive of *C. macrodonta* Whitfield from the Midway group (Eocene) of the Gulf region.

In recording this new evidence of the Eocene age of the Rancocas group, it is appropriate to call attention to evidence presented in three papers that have appeared since the publication by Cooke and Stephenson (2).

In 1930, Wetmore (5) critically reviewed the stratigraphic occurrence of eight species of fossil birds from supposed Cretaceous beds in New Jersey. He found that all came from the Hornerstown marl, the lower of the two formations composing the Rancocas group, and he concludes:

> From what has been said above it is evident that all of the supposed Cretaceous birds of the New Jersey marl beds are in reality from Tertiary deposits since they appear to come from the Eocene. They will be so indicated in the list of fossil birds to be included in the fourth edition of the "A.O.U. Check-List" now in course of preparation. With these forms allocated in the Eocene there is more logic in including them under families of birds with species existing today, procedure that to the writer has seemed dubious while they were considered of Cretaceous age since it is his present belief, based on what is known of the Hesperornithiformes and the Ichthyornithiformes, the only Cretaceous birds in which the skulls have been found, that all Cretaceous birds possessed teeth, and were for this and other reasons not so closely allied to living species as to permit their inclusion in living families.

In 1935 Miller and Thompson (6) discussed the significance of *Aturoidea* in the Hornerstown, Vincentown and Manasquan formations of New Jersey as follows:

> Although representatives of the genus *Aturoidea* have been found in beds which are clearly Upper Cretaceous in age, the Upper Cretaceous and the so-called Danian forms from India and northern Africa are very much more primitive than are the definitely Eocene forms, *A. parkinsoni* and *A. spathi*. As can be seen by comparing the figures on plates 65 and 66, *A. paucifex* and *A. pilsbryi* are strikingly similar to *A. parkinsoni* of the London clay (Yprésien), which has been correlated by some authors with the Aquia formation of Maryland and the upper portion of the Wilcox group of the Gulf Coastal Plain. *Aturoidea spathi* of the Eocene Ranikot series of India also appears to be very closely related, and although these four species came from three widely separated localities, the fact that they are very closely similar indicates that the beds which yielded them are probably not greatly different in age.

Jennings' (7) conclusions (1936), based on the microfauna of the Monmouth group and of the Hornerstown marl of the Rancocas group, add confirmatory evidence of the Eocene age of the Hornerstown.

Kummelia Stephenson, n. gen.

Type species: *Gastrochaena americana* Gabb.

The proposed new genus *Kummelia* is a sand-boring pelecypod that secreted an inclosing, long, tapering, more or less irregular tube characterized

by rather widely spaced annular grooves of somewhat irregular trend around the tube. The spacing of the grooves ranges from 2 to 7 millimeters, and the angle of divergence of opposite sides of the tube is approximately 6 degrees. The small end of the tube is not complete in any of the available material. The large end of the tube is sealed over in adults. The shell found within the tube is elongated, subtrigonal in outline, and is widely gaping posteriorly, ventrally and anteriorly. In form it closely resembles the shell of the Recent genus *Roscellaria* Blainville, whose tube in contrast is short, irregular, roughly bottle- or jug-shaped, and is rendered even rougher in appearance by the adherence to its outer surface of sand grains, fragments of shells, and other extraneous matter.

In its habit of growth this bivalve began at a young stage to bore in the sand and to construct a protecting tube of calcium carbonate around itself. As it bored deeper and grew larger it gradually increased the size of its tube and eventually reached a size such that it could not escape backward out of its self-constructed prison; however, it maintained connection with the outer world, that is with the water above the small end of the tube, by means of an elongated siphon. As shown by the position of the shell in the large incomplete tube illustrated in Figures 6–8, the animal was able to back up a distance of at least 34 millimeters from the basal, or large end. In other tubes the shell is at the base. In all cases observed the forward end of the shell is directed toward the large end of the tube.

For further details see the following description of the type species, *Kummelia americana* (Gabb).

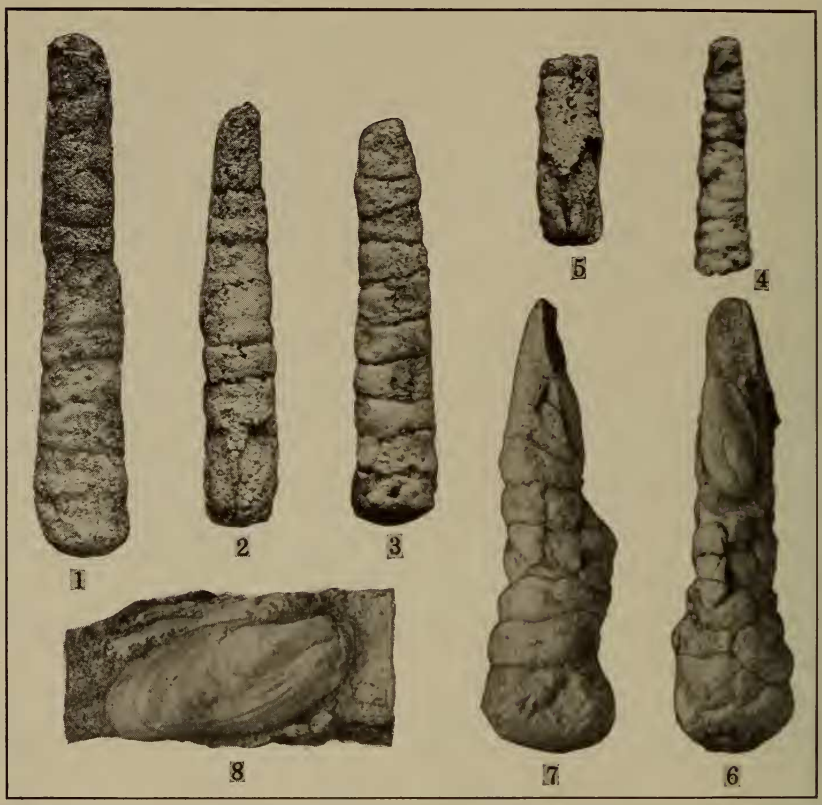
The genus is named in honor of Dr. Henry B. Kummel, Director of the Department of Conservation and Development of New Jersey.

Kummelia americana (Gabb), n. comb. Figs. 1–8

1860. *Gastrochaena americana* Gabb, Acad. Nat. Sci. Philadelphia, Jour., 2d ser., vol. 4, p. 393, pl. 68, fig. 20.
1861. *Polorthus americana* Gabb, Acad. Nat. Sci. Philadelphia Proc., vol. 13, p. 367. (In part.)
1872. *Polorthus americanus* Gabb, Acad. Nat. Sci. Philadelphia Proc., vol. 24, p. 259, pl. 8, fig. 8. (In part.)
1885. *Gastrochaena americana* Gabb. Whitfield, U. S. Geol. Survey Mon., vol. 9, p. 203, pl. 26, figs. 17, 18 (in part). (New Jersey Geol. Survey, Paleontology, vol. 1, p. 203, pl. 26, figs. 17, 18, 1886.)
1905. *Gastrochaena americana* Gabb. Johnson, Acad. Nat. Sci. Philadelphia Proc., vol. 57, p. 18.
1907. *Gastrochaena americana* Gabb. Weller, Geol. Survey New Jersey, Paleontology, vol. 4, p. 649, pl. 73, fig. 13.

The following is Gabb's original brief description of the tube of this species: "Elongated conical; transversely wrinkled; termination of widest end, round. Length 2.5 in., greatest diameter 0.5 in. Common in the yellow limestone [Vincentown] of Timber Creek, and found with the above species [*Teredo irregularis*] in the brown marl [Hornerstown] of Burlington Co., N. J."

In the collection of the Academy of Natural Sciences of Philadelphia is a tray containing 8 incomplete internal molds of tubes apparently representing as many individuals, labeled *Gastrochaena americana* Gabb (A.N.S.



Figs. 1–8.—*Kummelia americana* (Gabb). 1, a tube, the largest among the 8 cotypes (A.N.S.P. no. 13403); this is probably the specimen which served as the principal basis for Gabb's original drawing, which, however, appears to have been partly restored at the small end on the basis of the smallest cotype. 2, one of the cotypes (A.N.S.P. no. 13403), a tube with impressions of the two valves of the shell, uncovered at the large end. 3, 4, tubes from the Vincentown sand of New Jersey (U.S.G.S. Coll. 17282), showing the characteristic annulations (U.S.N.M. 496382). 5, a tube in the same lot as the preceding, showing impressions of the two valves of the shell, uncovered at the large end. 6, 7, an incomplete tube and shell from the Aquia formation ¾ mile west of Oak Grove, Prince Georges County, Md. (U.S.G.S. Coll. 16014); just prior to the animal's death it had backed up a distance of 34 mm from the large end of the tube (U.S.N.M. 496381). 8, an enlarged view of the shell, a right valve, in the tube shown in the two preceding figures.

No. 13403). I am indebted to Dr. Henry A. Pilsbry for the privilege of examining and redescribing Gabb's types. The largest of the specimens, marked "type" in faded ink, is 69 mm long, 12.5 mm in greatest diameter, and 7 mm in least diameter (Fig. 1); this tube is shorter than the original figure, which is 76 mm long, but is longer than the dimensions (2.5 inches) given by Gabb. The small end appears to be freshly broken and the tube may have met with an accident subsequent to the drawing of the original figure, which appears to represent a tube more symmetrical and smoother than the supposed type; however, the drawing may have been somewhat generalized. A small label in the tray in Gabb's handwriting reads: "*Gastro-*

chaena americana Gabb, Timber Creek, N. J. Types." The word *Gastrochaena* has been crossed out in pencil and the word *Polorthus* written below it, apparently in the same handwriting. All the specimens have the characteristic annular rings more or less clearly impressed upon them. The large end of the tube marked "type" bears indistinct markings which appear to pertain to the forward end of the inclosed shell. On the large end of another specimen in the lot the forward end of the shell was unmistakably exposed and was subsequently uncovered by the present author (Fig. 2); it is rather poorly preserved. These evidences of the presence of shells within the tubes were not recorded by either Gabb or Whitfield.

The following description is based on the type material, supplemented by 7 specimens in the U. S. National Museum labeled "Vincentown sand" (without further locality description), one specimen collected by the writer from the Vincentown sand on Crosswicks Creek, N. J., and one specimen from the Aquia formation near Oak Grove, Md.; the shell is best preserved on the last mentioned specimen.

Tube long, slender, tapering, circular in cross section, with sides diverging downward at an angle of approximately 6 degrees. The tubes vary from nearly straight to slightly and irregularly sinuous, and are marked by a series of transverse, irregularly spaced, suture-like grooves, at vertical intervals of 2 to 7 mm; the outer surface is more or less rough and irregular. The tubes have a maximum measured diameter of 18 mm and an undetermined minimum diameter of less than 4 mm. Complete adult tubes may have exceeded a length of 120 mm. The large end of the tube of adults is sealed over with a layer of calcium carbonate; it is broadly rounded, becoming more sharply rounded on its perimeter. On corroded specimens the grooves are seen to mark the edges of transverse septum-like walls similar to the convex calcitic layer sealing the large end of the tube; these walls may have sealed the tube at the successive growth stages indicated by the grooves, and were centrally resorbed or mechanically removed sufficiently to permit the animal to advance during each new growth stage.

In the incompletely labeled lot in the National Museum the large end of a small tube contains the impression of a bivalve shell with both valves intact in a fair state of preservation (Fig. 5), and a better preserved shell is contained in the tube from near Oak Grove, Md. (Figs. 6–8). The shell is elongated subtrigonal in outline; although the valves appear to be partly spread apart ventrally, the shell was obviously widely gaping posteriorly, ventrally and anteriorly. The beaks are situated about 1.5 mm back of the sharply rounded anterior extremity; they are small, incurved, and prosogyrate. The umbonal region is broad and only moderately prominent, descending steeply in front; it forms a broadly rounded inflation which extends backward and slightly downward, broadening and fading out toward the lower posterior extremity.

Hinge line long and straight, antero-dorsal margin short, slightly descending; anterior margin sharply rounded above, curving less sharply into the long, broadly rounded, slightly sinuous ventral margin; posterior margin sharply rounded below, curving broadly into the dorsal margin above. The dorsal margins of the two valves found form a keel of moderate prominence toward the posterior end of the hinge. Hinge and interior features not uncovered. Surface of shell marked by irregularly developed, low, moderately coarse, concentric wrinkles which are strongest anteriorly below the umbonal inflation.

The incomplete tube from near Oak Grove, Md., is larger than any of

the available New Jersey specimens. It measures: Length 61+ mm, maximum diameter at the large end 18 mm. The right valve of the shell in this tube has been uncovered in a fair state of preservation; at the time of the animal's death it had backed up until the front end of its shell was 34 mm above the large end of the tube. The shell is 17 mm long and 9 mm high. The tube exhibits the same sort of irregular annulations as those on the tubes from the Vincentown sand; although the Maryland specimen is incomplete and imperfectly preserved, both the tube and shell characters are essentially like those of the New Jersey specimens, and there is no reasonable doubt of their specific identity.

The shell of *Kummelia americana* lacks the square anterior truncation of *Gastrochaena* and has a broadly rounded ventral margin instead of a nearly straight one. The tubes of the two genera are also markedly different. *Gastrochaena* has a straight, regularly tapering tube marked by numerous closely-spaced, regular annulations; the tube of *Kummelia* has a rougher exterior, is more or less sinuous, and is characterized by much wider annulations separated by grooves of irregular spacing, which pass around the tube in an irregularly sinuous trend. The genotype of *Gastrochaena* is *G. mumia* Spengler, a Recent species.

The known material of *K. americana* includes the following:

A.N.S.P. no. 13403 (types). Vincentown sand on Timber Creek, N. J.; this creek forms the boundary between Camden and Gloucester Counties.

U.S.N.M. 496380 (U.S.G.S. Coll. 17279). Vincentown sand on a small east-flowing branch of Crosswicks Creek 0.7 mile north by west of New Egypt, Ocean County, N. J.; fragment of the large end of a tube 33 mm long, from within 10 feet of the base of the formation. Collected by the author, October 10, 1936.

U.S.N.M. 496382 (U.S.G.S. Coll. 17282). Three figured specimens labeled "Vincentown sand," with no additional information as to locality; the material doubtless came from New Jersey. U.S.N.M. 496383 (U.S.G.S. Coll. 17282). Four unfigured specimens from the preceding lot.

U.S.N.M. 496381 (U.S.G.S. Coll. 16014). Aquia formation in a road cut on the west-facing slope of the valley of the West Branch of Patuxent River, 3/4 mile west of Oak Grove, 2.6 miles west of Leeland, Prince Georges County, Md. Collected by J. B. Reeside, Jr., 1931.

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